GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

Highway Planning and Research
Department of Transportation
St. John's, Newfoundland

DEPARTMENT OF TRANSPORTATION
PLANNING AND RESEARCH DIVISION

MOOSE VEHICLE COLLISIONS IN NEWFOUNDLAND

RESEARCH REPORT NO. 34

Heather Miller
Research Assistant
December, 1985

TABLE OF CONTENTS

	page
SYNOPSIS	i
INTRODUCTION	1
MOOSE PHYSIOLOGY	2
MOOSE VEHICLE COLLISIONS - THE PROBLEM	4
MITIGATING MEASURES	6
A. ANIMAL CONTROL	7
1. Fences and Ancilliary Structures	7
a. Fencing	7
b. Ancilliary Structures	8
Utilization of Fencing and Ancilliary Structures in Newfoundland	9
2. Reflectors	10
a. Swareflex	10
b. Van de Ree	11
c. Stratolite	12
Possible Use of Reflectors	13
3. Salt Substitutes	14
Alternatives to Salt in Newfoundland	16
4. Sound Deterrents	16
Whistles in Newfoundland	17
5. Repellents	18
Repellents in Newfoundland	19
6. Vegetation Modification	20
Vegetation Modification in Newfoundland	21
7. Behavioral Stimuli	22
Study of Behavioral Stimuli in Newfoundland	23
8. Brightly Lit Highways	23
Application of Highway Lighting	24

B. DRIVER AWARENESS 25
1. Signage 25
Signage in Newfoundland 27
2. Reduction in Speed Limit 28
Reduction of Speed Limit in Newfoundland 29
3. Public Information 29
Initiation of a Public Information in Newfoundland 30
CONCLUSION 31
RECOMMENDATIONS 32
FOOTNOTES 34
BIBLIOGRAPHY 39

APPENDICES
Appendix A - Moose Physiology
Appendix B - Moose Accident Statistics
Appendix C - Fencing
Appendix D - Reflectors
Appendix E - Salt Alternatives
Appendix F - Sound Deterrents
Appendix G - Behavioral Stimuli
Appendix H - Signage

SYNOPSIS

According to police records and Wildlife Statistics, 264 moose vehicle collisions occurred in 1983, 2.6% of the total accidents for that year. In these moose collisions, 61 people had been injured while 8 were killed. Most of the accidents on record occurred on clear nights between 2000 and 2300 hours. Accidents for 1983 had been distributed throughout Newfoundland however two major areas were the Trans Canada Highway between the junction of Route 61 and Butterpot Park Entrance and, the TCH between the junction of Route 62 and Brigus Junction. The percentage of accidents for these two areas was 5.3% and 4.5% respectfully.

Review and analysis of the measures employed in other jurisdictions for similar situations resulted in the following recommendations:

- Initiation of a Public Information Campaign based on the wildlife pamphlet "When Driving at Night Think Moose". This should be a joint program between the Wildlife Division and the Department of Transportation.
- A 3 year test of the Swareflex Reflector should be undertaken on a 0.5 km section of the TCH between the junction of Route 62 and the Butterpot Park Entrance.
- Greater cooperation between the Wildlife Division and the Department of Transportation is required in the future.
- Implementation of a system for the recording of moose vehicle collisions in Newfoundland is necessary in order to obtain accurate accident statistics. Again this should be a cooperative effort between Wildlife and Transportation. For this purpose, the special studies section on a police report could be used.

INTRODUCTION

The purpose of this report is to determine a cost effective measure that can be used to prevent moose vehicle collisions in Newfoundland.

The report focuses on various measures that have been studied and/or implemented by various jurisdictions both within and outside of Canada. Comparisons and analysis of these studies are made and conclusions and recommendations presented.

MOOSE PHYSIOLOGY

Alces Alces, otherwise known as moose, is the largest member of the deer family and is deemed the largest antlered animal to have ever lived on earth.[1] Introduced to the Gander Bay Area in 1878[2] the moose can be found throughout the island of Newfoundland today.

Moose are non-sociable but docile animals. They are also non-territorial by nature. In Newfoundland, the home range of this ungulate usually averages 8-10 square km.

The moose, although lacking the regal dignity of the American Elk and the grace of the Whitetail, is far superior in intelligence.[3] In addition, he has excellent hearing and smell, two senses which greatly compensate for his poor vision. If disturbed, the moose is likely to analyze the situation before becoming alarmed. However, when an unusual sound is heard, he will look in that direction and, once convinced of the impending danger, will turn and flee the area. Thus, by listening and smelling upwind and by looking downwind the moose make full use of all senses in the detection of an enemy.[4]

The main enemies of the moose are the black bear, which has been known to easily kill an adult, and the wolf. The latter generally hunts in packs and attacks either on ice or in deep snow where the moose is most vulnerable. Wolverines and cougars, two other predators of the moose, usually prey on calves.[5]

The moose is well adapted to rough terrain and can often be found on rocky wooded hillsides, along lakes and muskegs, and along the streams of the great Boreal forest as indicated in Appendix A, Diagram A. However this animal prefers areas of second growth such as bogs, marshes, and lakes, especially areas where recent fires have laid way for such growth.

Moose live to be approximately 18 to 20 years old[6] and vary in color from dark brown almost black, to reddish or greyish brown with grey or white leg "stockings". The legs are long and slim and have cloven hooves. However, unlike other members of the deer family the moose can't jump, so when confronted by a high obstacle, the moose will rear up on its hind legs, place front legs over the object and leap over. Using this method, the creature can easily cross fences or other such objects of 6 to 7 feet in height.

A number of physical characteristics distinguish moose from the rest of the deer family. The body is deep at the shoulders and slopes off into a low rumped back ending in a short stubby tail. The head is large, and joins to a short heavy neck. Both the male and female have a piece of loose skin, known as a 'goatee" or "bell", hanging from the chin. The bell can be up to 12 inches long as depicted in Appendix A, Diagram B but is usually more predominate in the male.[7] When reaching full adult weight, usually 3 years of age, the moose will stand about 6 feet high. For females, the average adult weight is 325 kg whereas males roughly average 425 kg.[8]

Males will start to grow a set of antlers in late April and these will continue to grow until August. Antlers of yearlings look like 2 six inch spikes, however, two year olds have 2 points on each side called "crotch horns" and 3 year olds have 3 points on a side resembling small palms. The horns of 4 years olds assume adult form.[9] By September, the horns are completely developed and the moose is ready to do contest with other males as September marks the beginning of the rut, or the mating season.

The routine activities of the moose vary little between night and day so the moose will travel and eat by night as well as by day. However, the greatest degree of activity will occur at dawn and at dusk.

Since moose are herbivores, their diet consists of vegetable matter such as plants, shrubs, and trees but varies between seasons. In the spring and summer moose eat water plants such as water lily and vetch grass and in order to reach this food supply, they will dive to depths of 18 feet for up to 30 seconds at a time. However, due to the inaccessibility of such sources of food during the winter period, the moose will consume a large quantity of woody plants, balsam fir and white birch being two of the more favored. Because of the low nutritional value of the foods found in this diet, the moose must consume 50 to 60 pounds of food/day during the summer and 40 to 50 pounds of food/day during the winter. This herbal diet also contributes to nutritional deficiencies particularly of the minerals required to make milk and antlers. One such mineral which is needed and which constitutes only 5% of the browse consumed is sodium, a mineral dearly loved by the moose. Therefore in order to obtain this mineral, the moose will spend a great deal of time during the summer at "mud licks" or mineral springs churned up by the moose's feet.

The search for salt will also bring moose to the ponds near the roads which, due to winter salting and spring runoff, are rich in sodium. As a result, many of the moose that wander onto the road in search of extra salt are often killed. This is especially true in the spring period.[10]

MOOSE VEHICLE COLLISIONS - THE PROBLEM

Every year, many people are hurt and some killed as a result of moose vehicle collisions. In 1983, 264 accidents were recorded on Newfoundland highways, forming 2.6% of total accidents recorded on the island for this same period. The actual number of accidents far exceed the reported number of accidents annually and may even be double therefore, because

many accidents are never reported, the true number can only be estimated.

A number of people are hurt or killed annually in moose vehicle collisions. According to police reports for 1983, 61 people were injured in 47 moose accidents (17.8% of all moose collisions). These injuries constitute 3.7% of all injuries for this year. During 1983, 8 people were killed representing 7.8% of all deaths resulting from vehicle collisions (Appendix B, Diagram A). Injuries and fatalities from moose accidents exceeded the relative proportion of this type of accident, amongst those which occurred in 1983. Countermeasures to the moose vehicle collision will have a significant payback.

Because of the recent trend toward smaller cars, the number of injuries and deaths due to moose accidents can be expected to increase. Also because of this trend, the cost of property damage will also increase. According to Wildlife statistics[11] for 1984 (information for 1983 incomplete) a total of $401,692 was incurred in damages to vehicles.

Although moose vehicle collisions occurred throughout Newfoundland, two areas (Appendix B, Diagram B & C) of particularly high incidence were:

(A the section of TCH between the Junction of Route 61 and Butterpot Park Entrance - 13.4 km.

(B the section of TCH between the Junction of Route 62 and the intersection of Brigus Junction - 19.5 km.

In area A, 11 accidents were recorded during 1983, 5.3% of all accidents for that year. However, 4.5% of all accidents for the same period occurred in area B.

In 81% of the collisions, it was dark and, of these 54.3% occurred between 2000 and 2300 hours.

Although most accidents occurred at night, 32.2% of the recorded 1983 accidents took place between May and July 14% occurred during August (Appendix B, Diagram D).

In 61.4% of the accidents, weather conditions were clear. However, in 13.3% there were foggy conditions whereas, it was raining in 12.9% (Appendix B, Diagram E).

From 1974 to 1982, 1104 moose were killed in accidents.[12] In 1982, 42% of the moose killed in collisions with vehicles were male and 42% female. In 16% of the accidents, the sex of the animal was unknown.

Of all animal vehicle collisions for 1983, moose were involved in 80.98% and dogs in 7.36%. However horses, cattle, and cats were involved in 5.52%, 3.99% and 2.27% respectfully. At the bottom of this list were bears and sheep which were the cause of .91% of the accidents for the 1983 period.

Clearly moose are a problem on highways therefore some countermeasure must be implemented.

MITIGATING MEASURES

In recent years wildlife habitat, and behavior has become an important consideration in the planning and construction of new transportation corridors. This has not always been the case. Highways prior to the 1970's, particularly those in Newfoundland, were constructed with little consideration of their impact upon wildlife. Now, as accidents of moose vehicle collisions increase, mitigating measures must be taken to deal with the moose. To date a number of measures have been or are being experimented with in various jurisdictions. These can be broken down into 2 broad categories:

(1) animal control; and
(2) driver education and awareness

Each measure will be defined and described, followed by a discussion on the use within various other jurisdictions. A discussion of the possible effectiveness of each measure within Newfoundland will then be presented.

A. ANIMAL CONTROL

Methods included under this approach are:

1. Fences and Ancilliary Structures

(a) Fencing

Once a moose collision problem area has been identified, fences can be erected to either prevent the animals from wandering onto the road or to lead then to an under or overpass.

In the first instance, fences must be constructed so the moose will not be able to mount or walk around. Size and type of fence will be influenced greatly by biological and/or topographical conditions. There are two types of fences used in the prevention of ungalate mortalities:[13] leading fences which prevent animals from crossing roads at particular points; restrictive fences which prevent animals from gaining any access to the road. Fences can be chainlink, gloguard, electrical woven wire, or even a series of colored horizontal ribbons.

Studies

In 1973, Dale Reed, of the Colorado Wildlife Division, and his associates evaluated deer crossings on Interstate 70 near Avon and Edwards in Colorado where two 2.25 mile, 8 ft fences had been installed. Reed found the results encouraging as a 72% and 71% reduction of road kills occurred in these areas respectfully.[14]

In another study, Falk et al evaluated deer crossings in two areas. In the first area the fencing was in a good condition whereas the fence in the second area required repair. During the experiment, 247 crossings were recorded at site two as opposed to only six crossings at the first site.[15] Falk concluded that the fence was not effective when in need of repair.[16]

Bellis and Graves (1978) however found Falk's fence type to be totally ineffective regardless of its condition.[17]

In yet another evaluation, the Swedes found a 2 km long, 2 m high wire mesh fence, which they had installed on Highway 816, to be very effective.[18]

(b) Ancilliary Structures

Ancilliary structures such as underpasses, overpasses, and one way gates are most effective when used in conjunction with restrictive fences. Employment of underpasses allow the animal to cross to the opposite side of the road without endangering either himself or passing motorists. However, if an animal does manage to get onto the road corridor, one way gates prevent him from being trapped there. Enticement of ungulates and other animals can be accomplished by baiting the area around an underpass with some known palatable substance such as salt or browse.

Studies

Reed, Woodard, and Pojar (1975) conducted a study of the usefulness of a 3 m high, 3 m wide, 30 m long underpass in preventing accidents in Colorado. The underpass was used in conjunction with a 2.4 m fence and eight one way gates depicted in (Appendix C, Diagram A). During the four year study, Reed and his associates observed that 61% of the deer population had successfuly migrated back and forth via the underpass but, recordings of the approach of deer to this structure clearly showed their reluctance to enter. They concluded that due to the tunnelling effect produced, culvert type underpasses as indicated in (Appendix C, Diagram B) were not suitable. Bridge type underpasses were more appropriate as indicated in (Appendix D, Diagram C). Reed, Woodard, and Pojar also concluded that if culverts had to be used the floor surface should be gravel and artificial lighting should not be utilized.[19]

In another study by Reed, Woodard, and Pojar (1974), the effectiveness of one way gates was evaluated. During

this period, they reported that 323 deer which had managed to get onto the highway were able to safely escape via these structures.[20]

Overall studies with fencing have been fairly consistent placing them as the most effective method for prevention of collisions with wildlife.

Utilization of Fencing and Ancilliary Structures in Newfoundland

Fencing at selected areas of the TCH may prove to be the most effective measure for dealing with moose collisions however, due to the extremely high costs associated with it, this measure proves to be very cost restrictive.

Presently, a 2.5 m high chain link fence costs $47 per metre. Therefore to fence one km of highway on both sides would total $94,000. Also depending on which underpass type is used the cost will vary. Culvert type underpasses larger than 4 metres in diameter must be built using multiplate sheets. For 7 m high 7 m wide underpasses constructed of this, the cost per metre is $3,000. A bridge type underpass can be built at a total cost of $700,000.[21]

Clearly the installation of fencing and underpasses in a problem area such as that of area A (Appendix B, Diagram A and B) are astrononical, totalling $1,259,600 just for fencing.

In addition to this high cost, there are a number of other disadvantages associated with fencing:

- interrupts migratory pattern of all wildife, including moose
- require periodic maintenance
- reduces an aesthetic appearance along a road corridor
- with high snow moose will mount the fencing
- if an animal gets onto the highway it can be trapped

2. Reflectors

Reflective devices spaced evenly along the highway edge will draw light from the headlights of passing cars and as a result, should scare away nearby wildlife. Such devices can be used along problem areas or along the highway in general.

In a 1960 study in Holland, researchers found that light reflected from vehicle headlights could prevent deer from crossing the road.[22] During the last two decades a great deal of research has been conducted on three particular reflectors: Swareflex; Van de Ree; and Stratolite.

(a. Swareflex

Produced in 1973 by Swarovski Company, Austria, the Swareflex Reflector, illustrated in Appendix D, Diagram A is reputed to bring about an 80% reduction in animal vehicle collision once installed. The reflectors which are mounted in a plastic non-corrosive casing operate as follows:

> The headlights of approaching vehicles strike the wildlife reflectors which are installed on both sides of the road. Unnoticeable to the driver, these reflect red lights into the adjoining terrain and an optical fence is produced as indicated in Appendix D, Diagram B. Any approaching wildlife is alerted and stops or returns to the safety of the countryside.[23]

Studies

During the late fall to early spring period from 1981 to 1984, Swareflex reflectors were tested along SR 395 in Eastern Washington state. There were four test sites, each located in an area with a high deer vehicle accident rate. Initially, the reflectors of each site were alternately covered and uncovered for one week periods but as of December 1983, they were alternated at two week periods. During the study, 52 deer were killed at night in test sections when the reflectors were covered

whereas 6 deer were killed when reflectors were uncovered. The difference in deer vehicle collisions between covered and uncovered periods was significant (P ˙.005) indicating that Swareflex was effective.[24]

In another test of Swareflex, the Colorado Wildlife Division and Division of Highways set the reflectors up along Interstate 70 for evaluation. During the period of November 8, 1972 through April 23, 1973, the reflectors were alternately covered and uncovered for one week periods however, for the last month, the reflectors were covered for two weeks and then left uncovered for the remaining two. Results showed that 11 deer were killed when the reflectors were used while eight were killed when they were not. The study concluded that since 58% of the kills occurred while the reflectors were in use Swareflex were ineffective in reducing road kill.[25]

In 1978, 60 reflectors were set up along the TCH in Banff National Park's Duthill flat area. Prior to this period, 3 moose, 22 elk and 4 mule were killed from 1964-1977 however, during the course of this eight month study five elk were killed in the test area. As a result, effectiveness of Swareflex was questionable.[26]

(b) Van de Ree Mirrors

Unlike Swareflex, these deer mirrors are small 3" by 3" mirrors made of reflective metal that are mounted on posts about 1.06 m high depicted in Appendix D, Diagram C. They are spread approximately 60 to 90 metres apart along the road shoulder. The operation of this mirror is very similar to that of Swareflex however lights from approaching vehicles are reflected onto the right-of-way producing a twinkling light barrier.[27]

Studies

In 1973, the Saskatchewan government began testing of this European device. During the period of testing,

accidents which occurred at night, dusk, and dawn were recorded for each deer mirror installation, for the "control stretches"[28], and for each control section.

Accident information was broken into number of deer accidents after installation and, for five years before installation. "Percentage decreases" between the before and after groups and between the test and control sites were calculated. Positive net percentages indicated the mirrors were effective. Study results showed a positive net percentage for six sites but a negative net percentage in three. The four remaining sites showed no significant change (± 10% net change). Researchers concluded that the mirrors were effective.[29]

In 1969 the California Dept. of Fish and Game commenced a study along a section of Highway 70. Five kills were recorded during the first year, a drop from the average 20-31 kill average of the previous four years. However, the number of kills for 1970 again rose to this pre-installation level. Researchers concluded that although the mirrors were effective when installed, animals quickly became habituated to them.[30]

(c) Stratolite

Unlike Swareflex and Van de Ree, Stratolite are round, plastic convex mirrors of approximately 7.6 cm diameter. However, like the other reflectors, when the headlights of a vehicle hit this reflector a light is deflected.

Study

In a Missouri test, Stratolite mirrors were set up in an effect to prevent deer accidents. Results indicated a reduction in mortality but a report issued by the Missouri Department of Conservation stated that no vigorous study had been conducted on the effectiveness of the mirror.

In another test in 1965, Stratolite mirrors were set up on the highway in Calhaun and Jackson counties, Michigan. Because the road to Calhaun was new no change in animal vehicle accidents could be observed, however in the first year, accidents for Jackson dropped 26% at the test site but increased by 10% in the control site. During 1966 and 1967 respectfully, the kills increased 135% and decreased 30% for the test site while they decreased 23% and increased 88% for the control site. As a result, researchers could draw no conclusions.[31]

Possible Use of Reflectors

Of the three reflectors evaluated: Swareflex; Van de Ree; and Stratolite; Swareflex may be the most promising. However, since most of the research on Swareflex has been directed at the reduction of deer vehicle collisions, its effectiveness in reducing moose vehicle collisions as well as the behavior of a moose to this reflector is not known. But, given the fact that moose eyesight is bad, when the moose does see the optical fence produced by the Swareflex Reflector he will stop and size up the situation. Once he is convinced that it is safe the moose will then go on with his routine.

Swareflex, unlike fences, do not affect the migratory patterns of ungulates because the optical fence produced by the reflector is only temporary. Also, although many collisions occur at night, this fence will disappear once a vehicle has passed.

If Swareflex were to be used either on a permanent or test basis, the cost of purchase and installation is much lower per kilometre than fencing. Two sided reflectors sell for $15.75 each however special reflectors for testing can be purchased for $11.75 each. If regularly priced reflectors are bought in bulk, they are eligible for quantity discounts. Reflectors for testing can also be purchased on a specially reduced price

provided test results are made available to Strieter Corporation.

Therefore if Swareflex reflectors were installed along highway areas with high animal collision rates, such as the 13.4 km section between Route 61 and Butterpot (on the TCH) the cost would be:

	Per km	Total Cost
Regular Model	$1575	$21,475
Test Model	$1175	$15,275

In such case, a one to two kilometre test area would be best.

It should be noted that unless reflectors are periodically cleaned, dirt and grime buildup will greatly reduce their effectiveness. In addition to this, there are a number of other drawbacks associated with reflectors in general. These are:

- only useful after dark
- does not help if animal is already on the road
- ineffective on foggy/snowy nights
- subjected to vandalism and theft
- loose their reflecting ability because of corrosion
- are costly initially
- moose may not be able to see the reflectors[32].

3. Salt Substitutes

Salt and especially the sodium which is found in the conventional road salt used to deice highways has long been suspected as a major attraction of moose and other ungulates to road corridors. Therefore, by replacing salt with some other equitable substitutes, particularly in problem areas, moose will have no attraction to the roadside. Substitutes such as sand, urea, or calcium chloride (CaCl) could be considered. However, if salt must be used then salt licks, small amounts of salt, could be placed in selected locations away from the roadside.

Studies

In a study of the relationship between salt and moose accidents, Fraser and Thomas recorded the nature and distribution of roadside pools, moose acitivity at salty and freshwater pools, as well as seasonal variation of moose activity at salt water pools.[33] The study concluded that salt water pools were a major attraction to moose as these pools were heavily used. Fraser and Thomas also noted that most sightings of moose near highways and approximately half of the moose vehicle collisions occurred at or near salt water pools.[34] The study also indicated that "a reduction in the use of salt might have various benefits but would not likely eliminate salt related accidents involving moose"[35] as they will be attracted by even a small amount of salt. This, according to Fraser and Thomas, was especially true of sodium poor areas.

Studies by Garwin (1977) and Fraser (1980) indicated moose are attracted to artificial sources of salt. Also, Parchard (1946); Uecherman (1968); Rutherferd and Schmidt (1973); indicated when different salt mixtures were tested, those richest in sodium salts appear to be preferred.[36]

In their study Fraser and Thomas commented on various non sodium deicers.[37] According to them:

- urea is 10 times more expensive than NaCl (regular road salt). However urea is effective only down 6-10^{o}C as it is a fertilizer.
- ethylene glycol is more effective at lower temperature than urea, but is too expensive for highway use. Mixed results in studies done on it.
- calcium chloride (CaCl) usually used with NaCl (salt in areas of severe winter weather. It is very expensive. Effective to -34^{o}C.

Alternatives to Salt in Newfoundland

In 1983, 32.6% of the moose vehicle collisions in Newfoundland occurred between the months of May through July, a period when moose seem to be most strongly attracted to sources of supplementary sodium. Since a relationship exists between road salt and moose vehicle collisions in the province, use of non sodium deicers could reduce moose accidents. Table 1, Appendix E outlines the best alternatives to road salt, their costs, their composition and their effectiveness as deicers. Salt alternatives prove to be very expensive and are therefore cost prohibitive.

Placing of salt licks away from the road could also prevent moose vehicle collisions. However this cause of action is very impractical. There are two reasons for this. First, the two major moose vehicle collision locations, A and B, are very large and would therefore require numerous salt licks on both sides of the road. Second, the great number of collision sites just on the TCH make this measure impossible to execute. However an evaluation could be initiated to determine the number of salt water pools that exist in Areas A and B and the level of sodium in each. Wildlife should be approached for assistance on this matter.

4. Sound Deterrents

Because animals respond to various kinds and levels of sound, it is believed that devices which emit ultrasonic sound (> 20 Khz) or species specific sound, such as distress calls, will scare animals away from the road. However a great deal of the research done has been on ultrasonic sound.

Studies

In Sweden, a study to determine the upper hearing limit of moose was conducted. During this period,

four moose were placed in a large corral and their reactions to sounds of varying frequencies monitored. There reactions were classed as follows:

- does not react
- turns toward source but does not move otherwise
- reacts by fleeing

Upon completion of this experiment, researchers concluded that moose didn't hear frequencies higher than 21 Khz at a level of 70 dB.[38]

Sprock et al (1967) stated that the hearing range of most species do not exceed man's and are often even lower. In another study, Masterton (1969) indicated that the ability to hear high frequency sound decreases with increased body weight.[39]

In 1981 a study of whistles was conducted by the French Experimental Institute for Forestry and Agriculture in Ahvenjari. During the experiment they found that fallow deer, reindeer, bears, and canines all responded to a wildlife whistle whereas cattle and sheep didn't. Results indicated that the tones produced were not ultrasonic but of high frequency, approximately 17.5 Khz, and that the range of operation of these devices is questionable.[40]

Whistles in Newfoundland

Whistles are presently being used in Newfoundland. Bob Lake of Day and Ross Trucking states that since the installation of the "moose whistles" on their trucks in July, there have been no collisions with moose.[41] According to Mr. Lake many of his drivers have reported seeing the moose move away from the road as a truck approaches. Whistles installed on Wildlife vehicles have led to similar results

Moose whistles are easy to install and once a vehicle is travelling 50 kph or faster, ultrasonic sound

is emitted. Cost per whistle - Hobo Animal Warning Alert (Appendix F, Diagram A) is $19.95 and since two whistles must be used per vehicle, a total cost of $49.90 can be expected.

Based on previous data it appears that the whistle may be effective for the present however, since moose can hear all high frequency sounds and only some ultrasonic sounds, he may become habituated to the moose whistle.

5. Repellents

The use of chemical repellents on roadside vegetation would make an area much less attractive to the moose forcing him to look elsewhere for browse. All mammals respond to three kinds of odour:

(1) intraspecific odours used in communications
(2) those of natural enemies
(3) man made odours

Many researchers feel that compounds in all three groups can be used to repell ungulates however, only substances from group (3) such as Hinder and Big Game Repellent have been identified.

Studies

In a two part study carried out by the Ontario Department of Natural Resources, 15 substances[42] were tested for their repellancy to ungulates. The first stage, conducted in Sibley National Park, was broken into a series of trials. In each trial, five pans, each containing one litre of fluid, were placed near a salt rich spring: one pan held the spring water; two cantained 0.1 m of sodium chloride; two contained 0.1 m of sodium chloride mixed with one of the 15 substances. During the two year test each substance was tested anywhere from 6-17 times. At the end of phase 1, BGR was selected for further tests in phase 2. In this second phase, held near Wawa Ontario, BGR had been used on 56 salt pools in

order to evaluate its ability to repell ungulates from these areas. Upon completion of the entire study researchers concluded that putrescent egg (BGR), cattle manure, creosote and isobutryric acid were the four most effective repellants and, that BGR shows great promise as a deterrant to ungulates.[43]

In a study carried out by Sweden, the response of moose to 10 different scent repellents was evaluated through three test methods, each using repellent covered tin cans. Study results indicated that the scent cans did have an effect on moose, at least for a period of time, but gave no indication of whether the moose would become habituated to them.[44]

Generally, studies indicate that thiram is less effective than BGR or Hinder.[45] However, although many studies show promising results, all recommend further study as the period of effectiveness for repellants is unknown.

Repellants for Newfoundland

Although BGR has not been used in Newfoundland, Hinder has. In the summer of 1984 Wildlife officials tried to prevent moose from getting on the property of Tuckers Farm, Markland, by spraying Hinder on the vegetation. During the evaluation period, the repellent appeared to be effective against moose but, numerous applications had to be made because of rain.

Hinder is effective and has proven to be so against moose in Newfoundland. BGR, however, has not been tested. Also, Hinder is ideal for application in large areas as opposed to the localized application required for BGR.

Although Hinder can be obtained from the Halifax distributor, it is less expensive if purchased from the supplier, OK Chemical in California. BGR can only be used under the authority of a research permit in Canada and can

be purchased from Flora and Fauna Co. in Minneapolis, Minnesota in the following sizes and quantities:

Liquid Kit	½ gallon	$14.50
	1 gallon	$25.00
	5 gallon	$75.00

Since one gallon of BGR covers 400-600 seed leaves, or approximately 5 metres, cost per kilometre for one application of this chemical is $6,000. This cost applies only to the cost of BGR and does not include labour.

There are some problems related to the use of repellents:

- they can attract flies and black bear
- they wash off in the rain

6. Vegetation Modification

Through clearing of vegetation and habitat manipulation, moose will be encouraged to look to areas other than roadway for browse. This can be achieved in three ways. First, clearing of roadside areas. Second, by reducing the attractiveness of roadside vegetation and third, by improving areas away from corridors.

Studies

In one study, Swedish researchers cleared a roadside area in order to determine how effective this was. However, results indicated that the increased visibility only created problems for drivers. Also, the risk of moose collisions did not decrease as the area between the road and wooded tract increased. Another conclusion reached by researchers was that clearing of roadsides only made the area more attractive to animals. Overall, it was concluded that clearing does not result in any significant change in collisions.[46] Watson et al, (198[illegible] indicate five types of vegetation which are of low palatability to ungulates: streambank wheatgrass;

red top; sand grass; pine grass; and salt grass. Of these, streambank wheatgrass had the lowest palatability. However, research has shown that regardless of the degree of palatability, ungulates will adjust to any vegetation and, eventually consume it. Therefore, if palatable species are used, an area away from the road should be enhanced. In doing so, the attractiveness of the road corridor will be reduced.[47]

The third form of habitat manipulation, burning, has been studied extensively in the U.S. According to Einarsen (1946) the vegetation resulting from a fire has more nutrition than the same species located in older forest. A study by Hardy and Associates (1982) also indicated that the time of a burning is crucial. Burning should not be used during calving and mating seasons.[48]

Vegetation Modification in Newfoundland

Of the three methods of vegetation modification, only one, to date, will be studied in Newfoundland. During the 1985 summer, officials from the Wildlife Division began clearing brush excluding the Balsam and fir from a 1400 m area of TCH near Soldiers Pond. Upon completion of the project in the summer of 1986, a two year study of the effectiveness of this measure will be undertaken.

An alternative to cleaning the brush away is the elimination of palatable vegetation, and replacing it with unpalatable grasses. Ideally this vegetation would be planted when a corridor is being built.[49] However, as the TCH already has right of way grass cover, the existing grass must be overturned prior to planting the unpalatable vegetation. But, grasses along the highway are special combinations designed to prevent soil erosion along the roadside as well as the eventual disturbance of the highways due to such erosion.[50] In light of this,

unpalatable species may be unsuitable. Also, of the five species of grasses recommended earlier, redtop is the only one whose seed is commercially available.[51] All five grasses are wild. In addition, there is no guarantee that the moose will not become habituated to these new species.

The use of burning to enhance areas away from the roadside may not be feasible either. This is mainly due to the large area of Boreal forest in Newfoundland - which moose love. Also, because of the dispersion of moose vehicle collisions over the island, burning would have to be carried out in a number of areas.7.

7. Behavioral Stimuli

The theory of behavioral stimuli is that species specific stimuli can be used to scare ungulates away from the road. There are two such types of stimuli:

- stimuli which an animal innately responds
- stimuli which have been associated with unpleasant experiences

With the first type, symbols or models of other animals, such as a natural enemy, could be used to stimulate a flight response in an ungulate. However, very little information is known of the latter type of stimuli.

Studies

Bayshore (1975) evaluated the response of deer to a model simulating a deer with its hind tail raised - a universal warning of danger to other deer[52] depicted in Appendix H, Diagram A. These models were placed along deer trails crossing rural roadside during the course of the experiment, deer tracks in both test and control sites were counted. The study concluded that deer did avoid these areas where models had been placed.

However, the results obtained by Bellis and Graves (1978) were not so positive. In this study, deer counts

at the control and experimental sites were made during each of the four experiments (as with Bayshore). The first experiment proved inconclusive because too few deer passed through. In the second experiment, six variations of the deer model were used but no difference was detected between them. However, more deer passed through areas where no model was placed. In the third and forth experiments, which were conducted over an eight month period, the models did not prevent deer from crossing. Therefore, Bellis and Graves concluded that the models didn't work.

Although the same approach was used by Bayshore and by Bellis and Graves, the differences in the time of year and in the type of roadway used are considered to be a major factor[53] in study results.

Study of Behavioral Stimuli in Newfoundland

Use of behavioral stimuli may prove to be very successful in preventing moose vehicle collisions in Newfoundland. However because of the limited amount of research in this area and because research has primarily been conducted in the deer population, the effectiveness of this measure on moose in this province is not known.

Therefore a study using a model of a natural predator of the moose, such as the bear should be implemented in Newfoundland to determine how effective this measure is. Again areas A or B could be ideally used.

8. Brightly Lit Highways

It has long been believed that if a highway is brightly lit, animals will stay away from the roadside as the lights make them insecure and unwilling to expose themselves to unnecessary danger. It is also believed light will increase the driver's vision. Research of this theory has been relatively limited.

Studies

Reed et al, wishing to test whether fixed illumination would increase night vision and reduce deer vehicle collisions, set up a study along State Highway 82 in Colorado.

In this test, thirteen 37,000 luminous 700 watt clear mercury vapor lamps were placed at the top of 12.2 m metal poles. Nine poles were spaced approximately 60 to 70 metres apart and, at the end of the full lighting, additional lamps were spaced at approximately 120 m and 300 m to create an area of transition lighting. In all the transition lighting took up a 1.2 km section of highway.

These lights were alternatively turned on and off for one week periods. During this time, the estimated number of deer crossings and vehicle speeds were recorded.

Researchers concluded that highway lighting "did not affect the location of deer crossings". They also concluded that highway lighting was not a recommended mitigating measure to deer vehicle collisions.[55]

In another study, Huculak (1974) tried to determine whether conventional vehicle headlights were able to distinguish an animal from a sufficient distance using a cowhide target on a roadway. He concluded that, under lowbeam headlights an object could only be detected at a distance of 60 m or less.[56]

Application of Highway Lighting

Installation of highway lighting may result in increased moose crossings at an area. Also, because of the intensity of regular lighting some form of transition lighting is required to help a driver adjust to the change from complete darkness to light. This kind of lighting is needed because a driver may not see a moose on the road when the driver is just entering, or just leaving, a well lit area.

Also, once exposed to highway lighting of this nature, the driver's night vision is impaired for a period of time. This would increase the risk of moose collision, especially in identified high risk areas, as the driver will not be able to see a moose.

The costs of implementing such a measure are very high and effectiveness in reducing animal vehicle collisions is doubtful. For the above reasons, highway lighting is not recommended to be used as a mitigating measure to moose vehicle collisions.

B. DRIVER AWARENESS

1. Signage

Signs warning of the possibility of animals on road corridors have been used by many districts as a measure against animal vehicle collisions. In recent years, however, research has begun to focus on various forms of signage in an effort to determine if signs really do work and, if so, what form of signage is most effective. Three types of signs, in particular have received a great deal of attention. These are silhouettes, light animated crossing signs, and microwave devices.

Studies

In a Swedish study at Uppsula University in 1979 reactions of drivers to randomly placed game warning signs were measured. In 37% of the cases drivers spotted the signs however, this was a 50% drop from a similar experiment in 1959. Researchers concluded that increased signage over the years has reduced driver observation. They also concluded that because a driver rarely encounters ugulates in these high risk areas the signs tend to be ignored.[57]

In 1983, an effort by officials of Yoho National Park to reduce the number of elk collisions resulted in the establishment of elk silhouettes along high risk

areas. At that time, one elk silhouette had been set up but was followed by a variety of similar signage shortly afterward. Evaluation of the various silhouette signs led to the following conclusions:[58]

- panal type signs with a reflective elk silhouette on one side tend to become unrecognizable when snow collects on it (Appendix H, Diagram A)
- non reflective elk silhouettes (Appendix H, Diagram B) cannot be seen by motorists until they are upon them
- reflective surface (scotchlite) elk silhouettes (Appendix H, Diagram C) are the most effective as they can be seen up to 1 km away
- introductory signs are effective in alerting motorists about the silhouettes (Appendix H, Diagram D)
- the elk silhouettes, reflective and nonreflective could be seen from both sides of the road.

Although these signs have been in place since 1983, the study will not be completed until after the 1985-86 year. However, park authorities have stated that since implementataion of this signage there has been a 30% decrease in the number of elk collisions.[59]

In yet another study, the effectiveness of a lighted animated deer crossing signs (see Appendix H, Diagram E) was evaluated. During the study period, the frequency of deer vehicle collisions as well as the response of motorists were measured. Results indicated that the signs were not effective in reducing the number of deer killed. Results also showed that, in those instances where motorists reduced their speeds, the reduction was too small to be of any significance.[60]

Another experiment, carried out by Ward et al (1980), used a low power, narrow beam microwave transmitter and receiver which were placed approximately 365 feet apart on US Highway 30. Whenever a deer passed

between these sensors, a red sign with "deer" wrote on it would flash for about 2 minutes warning motorists of the danger. The sign had been placed 200 km away from the transmitter and receiver. This microwave device was alternatively turned on and off for irregular periods. Although study results were positive the need for more testing was indicated.[61]

Signage

Conventional signs warning of moose have been used in this province for a number of years however, to date, there has been no known evaluation of their effectiveness in preventing moose vehicle collisions. Therefore, since the only guideline for such an evaluation is the number of moose accidents, it can only by assumed that conventional signage is not effective.

Of the many varieties of signage tested within other districts, one is presently being evaluated within this province. On July 19 of this year, Terra Nova National Park officials erected (see Appendix H, Diagram F) six moose silhouettes along the Park's 25 mile section of TCH. Because they were only recently set up, the officials have not had sufficient time to evaluate their usefulness but, a report will be made once the study is complete.

The other forms of signage, animated crossing and microwave signs, have not been studied in any great depth and therefore their application and success on Newfoundland highways is not known. However, a study on microwave sensors in reducing moose accidents is presently underway in Sweden. Once completed the results of this study should be obtained.

In light of the above, moose silhouettes appear to be the only feasible alternative to conventional signage at present and, as initial reports from park authorities are positive, substitution of moose silhouettes for conventional signage could be considered.

Moose silhouettes and signage in general are:

- cost effective
- easy to erect
- easy to care for - require little maintenance
- are necessary in order to cover against public liability

However it should be noted that although signs appear to be effective at first - there is a good possibility that, once drivers have grown familiar with them, (new signs) moose vehicle collision rates may once again rise to previous levels.

2. Reduction in Speed Limit

In areas of known animal vehicle collisions, speed limits can be reduced prior to, and increased just after entering and leaving this tract. In doing so, the driver of a vehicle should have more time to react to animals on the road and, as well, will be more conscious of the possibility of animals nearby.

Studies

Damas and Smith state that animal vehicle collisions occur on roadways of low design speed as well as high but, in those corridors where speed exceed 60 kph a larger number of accidents occur. They also indicate that areas of 60 kph and less carry lighter traffic volume and, as a result have lower levels of traffic during the dawn/dusk hours. Damas and Smith therefore conclude that collisions with ungulates are as much related to vehicles on a particular road as they are with speed.[62]

In 1976 authorities of Banff National Park lowered the speed limit to reduce collisions with Big Horn sheep. During this 31 month test, accidents dropped from 118 (pre test level) to 56. The number of sheep killed during this time was 26, a decrease of only four from the pre-test level of 30. The study concluded that reduction in speed limit will not decrease the number of animal accidents.[63]

Reduction of Speed Limit on Newfoundland Highways

It is very doubtful that a reduction of the speed limit will reduce the number of moose accidents on Newfoundland highways. Because the number of collisions are the result of both the speed limit and the volume of traffic, reduction in the speed limit may cause more problems than it will solve. This is especially true of the TCH. In 1983, 47% of moose collisions had taken place along this corridor therefore as little can be done to lower traffic volume, a reduction of the speed limit will be pointless.

3. Public Information

In a large number of accidents drivers claimed the animal jumped in front of their vehicle before they had seen it.[64] By educating drivers about the possibility of moose vehicle collision and about moose behavior in general, these accidents can be averted. This can be achieved through the implementation of a public information program which not only will alert drivers to high risk areas but will also identify methods of spotting moose.

Studies

In Sweden, researchers evaluated knowledge of wildlife and detection. In 1977, a nationwide campaign, via all media, was launched to drivers on the behavior of ungulates and how they could avoid the risk of game accidents. Tests conducted before and after the campaign showed that drivers knowledge had already been good and that the effect of the campaign was marginal.[65]

In another experiment, researchers at Sweden's Uppsula University evaluated the effect of driver's knowledge of moose with moose vehicle collisions using standard drivers and hunters. Results showed hunters had fewer actual collisions with moose. The study concluded that those drivers who were familiar with moose behavior

and who used scanning techniques detected moose faster than those who didn't.[66]

Public Information Campaign in Newfoundland

A public information program should be considered for this province although a program of this nature will only produce limited results at first, a long term campaign aimed at all forms of media, particularly radio, will change public thinking. To ensure success of this program, it should include these three components:[67]

- definition of high risk areas including the locations and times of accidents
- explanation of the unpredictable behavior of moose
- information on how to avoid accidents through scanning techniques and through the use of caution when in, or near high risk areas.

A pamphlet entitled "When Driving at Night Think Moose", was recently put together by Wildlife officials. This document should be reviewed and included into the Public Information Campaign. This Program should be aimed at both the native Newfoundlander and the tourist.

CONCLUSION

In recent years, collisions between motor vehicles and moose have become a major problem on Newfoundland highways. As a result of these collisions, several people are hurt or killed annually. In 1983, 7.77% of the deaths and 3.65% of the injuries in traffic accidents were due to moose/vehicle collilsions. The total costs for property damages incurred each year due to these accidents is in the hundreds of thousands of dollars. Once a moose has been killed, it presents a hazard to the travelling public. Therefore costs associated with the cleanup of an accident and the disposal of the carcass are high.

To deal with this problem a Public Information Campaign should be initiated jointly by the Department of Transportation and the Wildlife Division. This program must include the three components for a public information program.

A three year study of the Swareflex Reflectors should be initiated in area B, identified earlier. Again this should be a joint project of Wildlife and Transportation.

A uniform system of recording moose accidents must be designed. This also should be a cooperative effort by Transportation and Wildlife employing the special projects section of the provincial motor vehicle accident report form.

RECOMMENDATIONS

In light of this study, the following recommendations should be considered:

- Review of Wildlife Information Pamphlet, "When Driving at Night Think Moose".

A joint review of this document should be made by the Department of Transportation and the Wildlife Division to ensure that it corresponds with the three components of a Public Information Program.

- Initiation of a Public Information Program

A Public Information Campaign based on either the Wildife Pamphlet or on an entirely different approach should be undertaken. This program should uncorporate all forms of media but especially the radio. The pamphlets must be distributed to both tourists and native Newfoundlanders.

- Test of Swareflex Reflectors

A three year test of the Swareflex should be conducted on a 0.5 km section of the TCH highway. The best area would be in area B, the section of TCH between the junction of Route 62 and the Brigus Junction.

- Behavioral Stimuli Study

This study should be conducted in area A, located on the TCH between the junction of Route 61 and the entrance to Butterpot Provincial Park. The behavioral stimuli model should resemble one of the natural preditors of the moose, such as the bear.

- Initiation of a Uniform System for Recording of Moose Vehicle Collisions

Presently, there is a large discrepancy between the moose accident statistics provided by Wildlife and by the police. Therefore, some system of recording these accidents must be developed by the Department of Transportation and

the Wildlife Division. The Special Studies Section of the police accident form could be utilized.

- Future Cooperation between Wildlife and Transportation

Since both are affected by moose vehicle collisions along Newfoundland highways, better cooperation between Wildlife and Transportation is necessary now and in the future.

- Review of Microwave Signage Study

The microwave devices now being tested by the Swedish government look very promising. Upon completion of this study, a copy of the results should be obtained and, if the study is successful, a similar test should be implemented in this province.

- Review of Moose Silhouettes - Terra Nova National Park

Upon completion of this study, results should be reviewed and, if proven successful, moose silhouettes should be erected in other areas of Newfoundland.

FOOTNOTES

1. Anonymous, "Life History of Alces Alces Americana", p1.

2. Anonymous, "Newfoundland and Labrador Wildlife Notes".

3. Samuel Merrill, The Moose Book, 2nd ed. (E.P. Dullon and Company, 1920), p67.

4. Ibid., p70.

5. Hinterland's Who's Who, Moose.

6. Samuel Merrill, The Moose Book, 2nd ed. (E.P. Dullon and Company, 1920), p173.

7. Ibid., p3.

8. Newfoundland and Labrador Wildlife Notes.

9. Samuel Merrill, The Moose Book, 2nd ed. (E.P. Dullon and Company, 1920), p177.

10. James MacNeil, The Moose Shop Moose Book (Highway Book Shop, 1975), pp 93-94.

11. Wildlife records pertaining to those accidents where Wildlife had been called to pick up a dead or injured moose. Wildlife statistics do not necessarily correspond with police records.

12. Wildlife Statistics.

13. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), p123.

14. Halle Flygare, Ungulate Mortality and Mitigated Measures, Trans Canada Highway, Banff National Park (May 1979), p40.

15. Of these 6 crossings, four had been made when the deer jumped the fence.

16. The fence was a type three modified consisting of woven wire mesh.

17. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Park (1981), p138.

18. Halle Flygare, Ungulate Mortality and Mitigated Measures. Trans Canada Highway, Banff National Park (May 1979), p44.

19. Halle Flygare, Ungulate Mortality and Mitigated Measures. Trans Canada Highway, Banff National Park (May 1979), p43.

20. Ibid., p45.

21. Costs provided by Terry McCarthy.

22. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), p216.

23. Swareflex, "Wildlife Warning Reflectors Save Lives of People and Animals".

24. Schafer et al, "Effectiveness of Swareflex Reflectors in Reducing Deer Vehicle Accidents in Washington State".

25. Halle Flygare, Ungulate Mortality and Mitigated Measures. Trans Canada Highway, Banff National Park (May 1979), p30.

26. Ibid., p31.

27. P. Heint, Deer Mirror Test Site Evaluations (July 1982), p1.

28. "Control Stretches" were areas approximately 4.8 km in length. These were located on either side of a deer mirror installation.

29. P. Hunt, Deer Mirror Test Site Evaluations (July 1982), p4.

30. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), pp 218-219.

31. Ibid., p219.

32. Halle Flygare, Ungulate Mortality and Mitigated Measures. Trans Canada Highway, Banff National Park (May 1979), p27.

33. Fraser et al, "Moose-Vehicle Accidents in Ontario: Relation to Highway Salt". Wildlife Society Bulletin (82), 262.

34. Ibid., p264.

35. Ibid., p264.

36. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), p179.

37. Fraser et al, "Moose-Vehicle Accidents in Ontario: Relation to Highway Salt", Wildlife Society Bulletin (1982), 264.

38. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), pp 243-244.

39. Ibid., p244.

40. Ibid., pp 245-246.

41. Interview with Mr. Lake.

42. These substances are thiram, BGR, isobutyric acid, ethanol, urea, creosote, liquid laundry detergent, mustard powder, NH_4Cl, $CaCl_2$, KCl, fresh cattle manure, stagmant water, and speckled alder extracts.

43. Fraser et al, "Moose-Vehicle Accidents in Ontario: A Repugnant Solution?", Wildlife Society Bulletin 10(3), (1982), p269.

44. Hallé Flygare, Ungulate Mortality and Mitigated Measures. Trans Canada Highway, Banff National Park (May 1979), p37.

45. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), p245.

46. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), p95.

47. Ibid., p295.

48. Ibid., p301.

49. Ibid., p298.

50. Cynthia Brenton, "An Evaluation of the Department of Transportation Hydroseeding Methodology", pp 6-7.

51. Personal comments Ross Traverse.

52. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), pp 320-322.

53. Ibid., pp 322-323.

54. Reed et al, "Effectiveness of Highway Lighting in Reducing Deer-Vehicle Accidents", J. Wildl. Manage. 45(3) (1981), 721.

55. Ibid., p725.

56. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), p90.

57. Ibid., p80.

58. E.R. Langshaw, "Ungulate Highway Mortality Mitigation Measures, Yoho National Park", (1985), p3.

59. The Evening Telegram, p6.

60. Reed et al, "Effectiveness of a Lighted Animated Deer Crossing Sign", pp 88-90.

61. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), p83.

62. Ibid., p77.

63. Halle Flygare, Ungulate Mortality and Mitigated Measures. Trans Canada Highway, Banff National Park (1979), p37.

64. Damas and Smith Wildlife Mortality in Transportation Corridors in Canada's National Parks (1981), p326.

65. Ibid., p327.

66. Ibid., p328.

67. Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks, p333.

68. Costs unless otherwise indicated, are provided by A.L. George, Highway Maintenance Engineer, Department of Transportation.

69. Costs are provided by Howard MacDonald, Transport Canada.

BIBLIOGRAPHY

Anonymous, "Life History of Alces Alces Americans" pp 1-10.

Brenton, Cynthia, An Evaluation of The Department of Transportation Hydroseeding Methodology, August, 1985.

Damas and Smith, Wildlife Mortality in Transportation Corridors in Canada's National Parks, 1981.

Fraser et al., "Moose Vehicle Accidents in Ontario: A Repugnant Solution?" Wildlife Society Bulletin, 10(3) 1982, pp 266-270.

Fraser et al., "Moose Vehicle Accidents in Ontario: Relation to Salt." Wildlife Society Bulletin, 10(3) 1982, pp 261-265.

Flygare, Halle, Ungulate Mortality and Mitigated Measures. Trans Canada Highway, Banff National Park, 1979.

Hunt, P., Deer Mirror Test Site Evaluation, July 1982.

Mackeil, James, The Moose Shop Moose Book, Cobalt, Ontario: Highway Book Shop, 1975.

Merrill, Samuel, The Moose Book. 2nd ed. New York: E.P. Dullon and Company, 1920.

Reed et al, "Effectiveness of Highway Lighting in Reducing Deer-Vehicle Accidents" J. Wildl. Manage., 45(3): 1981.

Reed et al, "Effectiveness of a Lighted Animated Deer Crossing Sign" J. Wildl. Manage., 39(1): 1975.

Schafer, James A. et al, "Effectiveness of Swareflex Reflectors in Reducing Deer-Vehicle Accidents in Washington State".

Swareflex, "Wildlife Warning Reflectors - Effective Protection Against Accidents on Highways".

APPENDICES

APPENDIX A - MOOSE PHYSIOLOGY

MOOSE VEHICLE COLLISIONS IN NEWFOUNDLAND

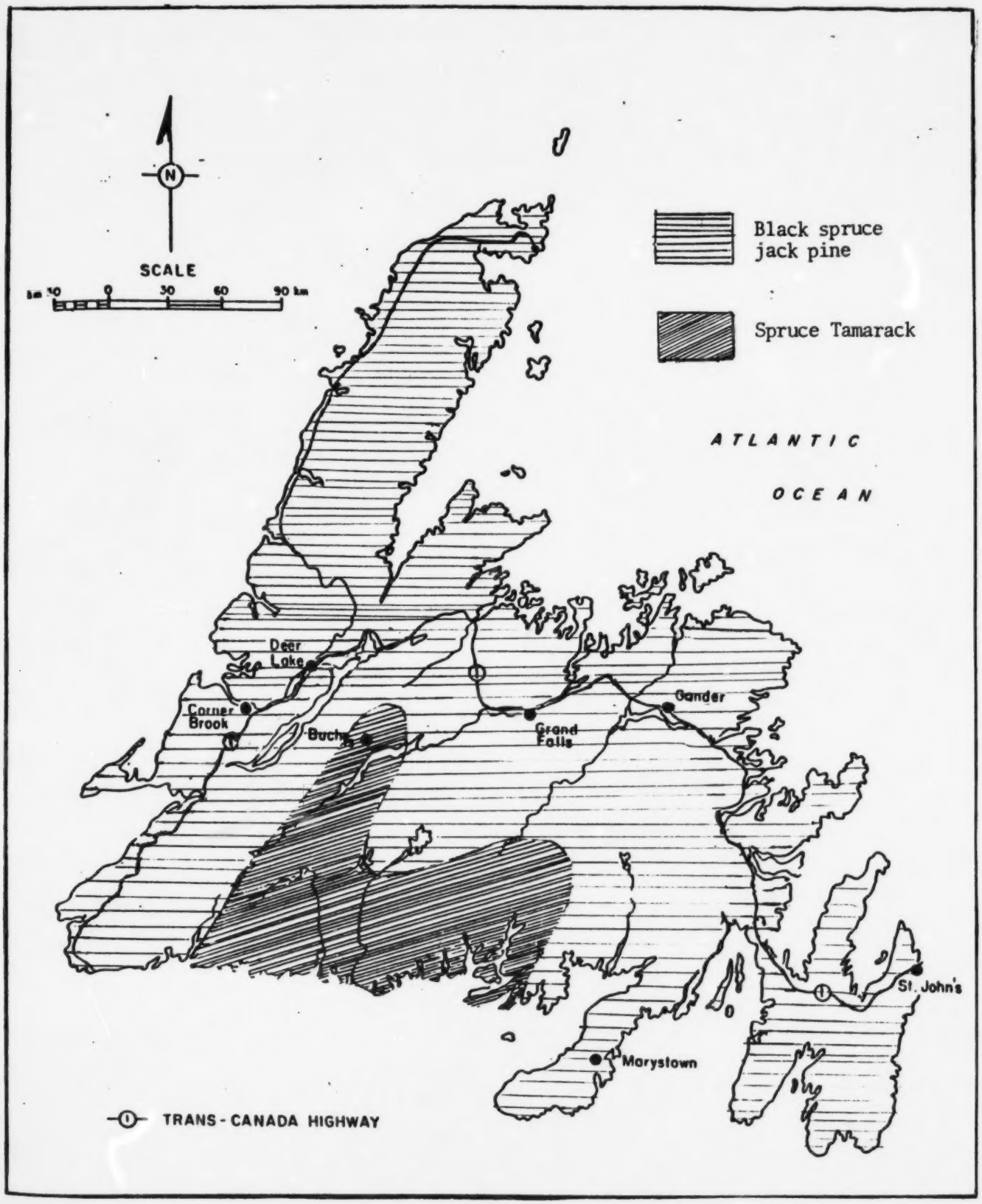


DIAGRAM A - Newfoundland Vegetation

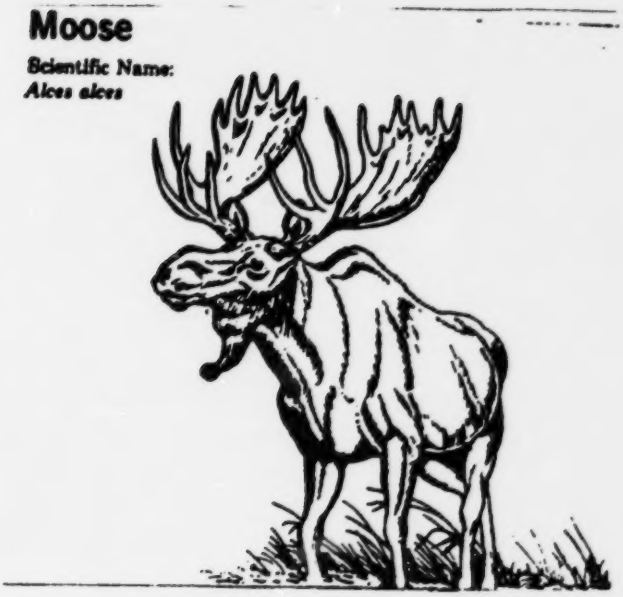


DIAGRAM B - Moose

APPENDIX B - MOOSE ACCIDENT

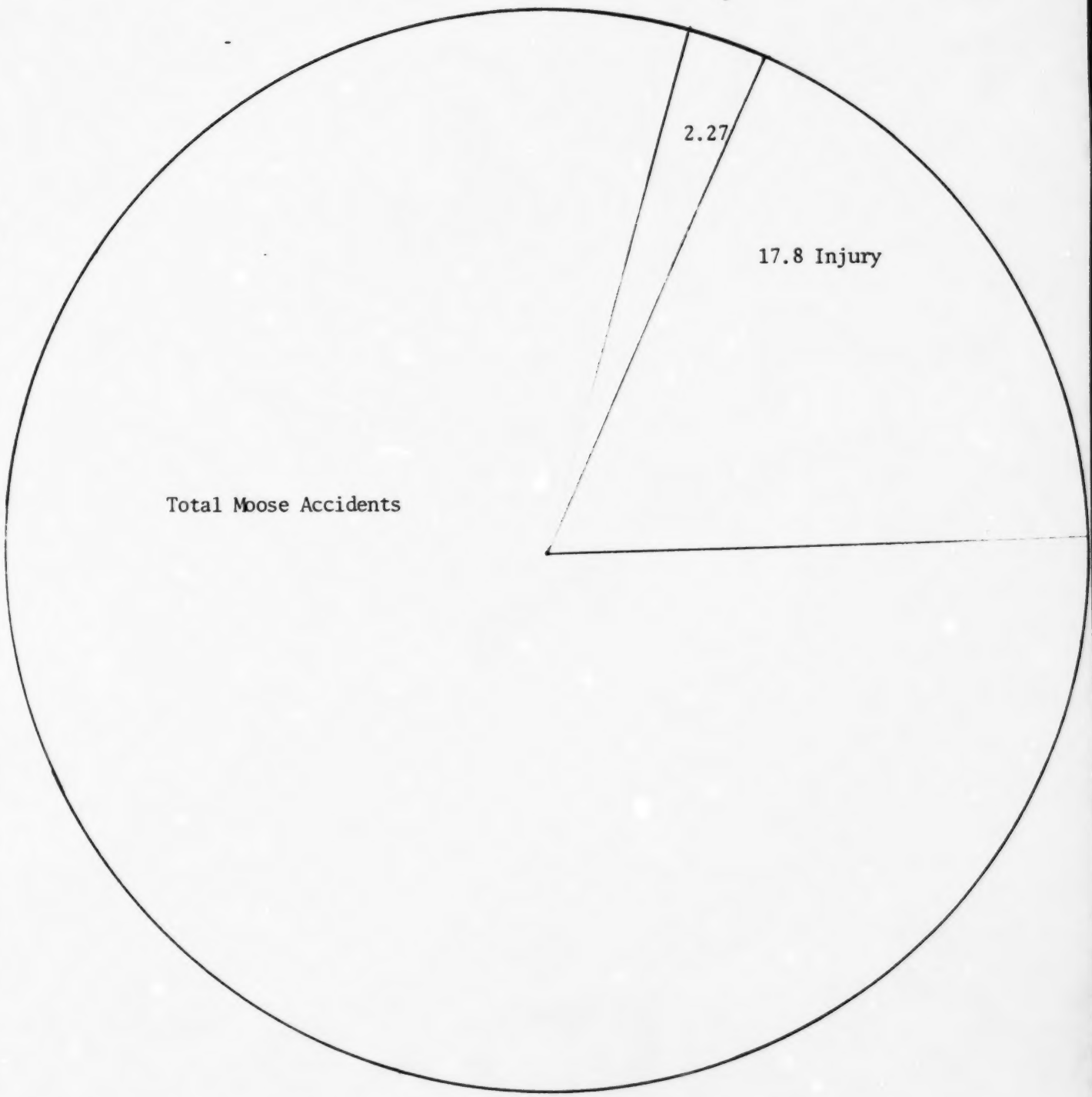


DIAGRAM A - Percentage of Deaths and Injuries for all Moose Vehicle Collisions.

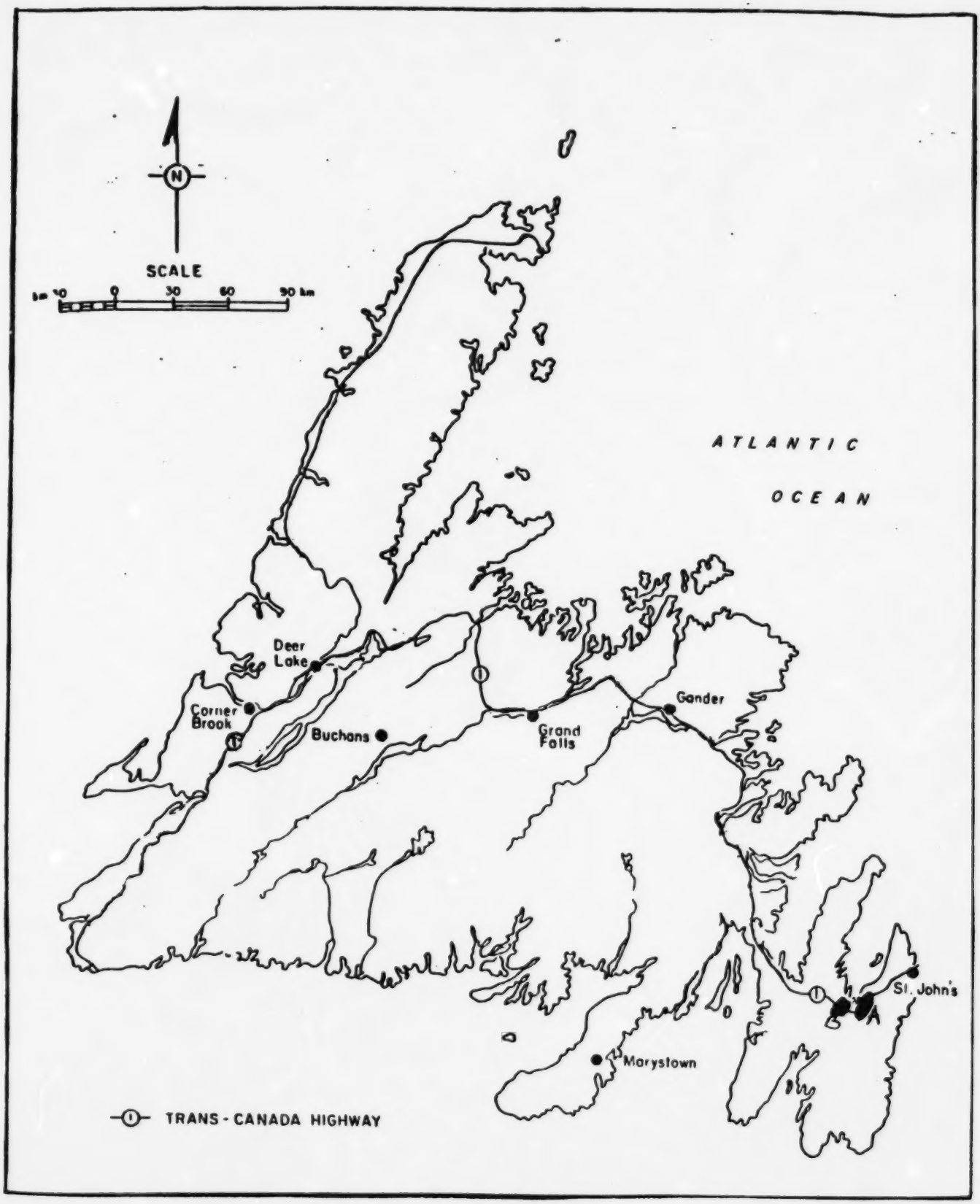


DIAGRAM B - High Risk Areas

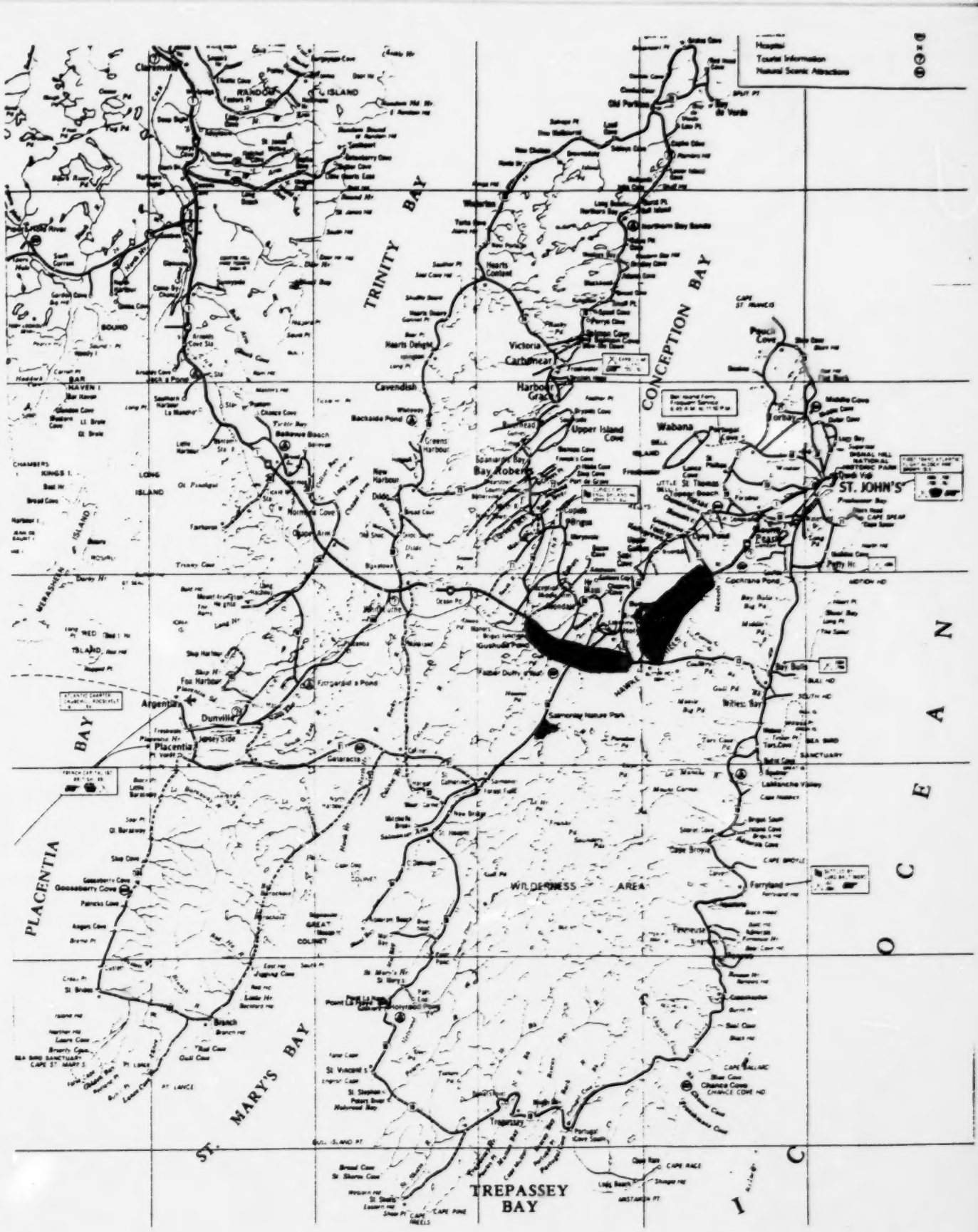


DIAGRAM C - High Risk Areas

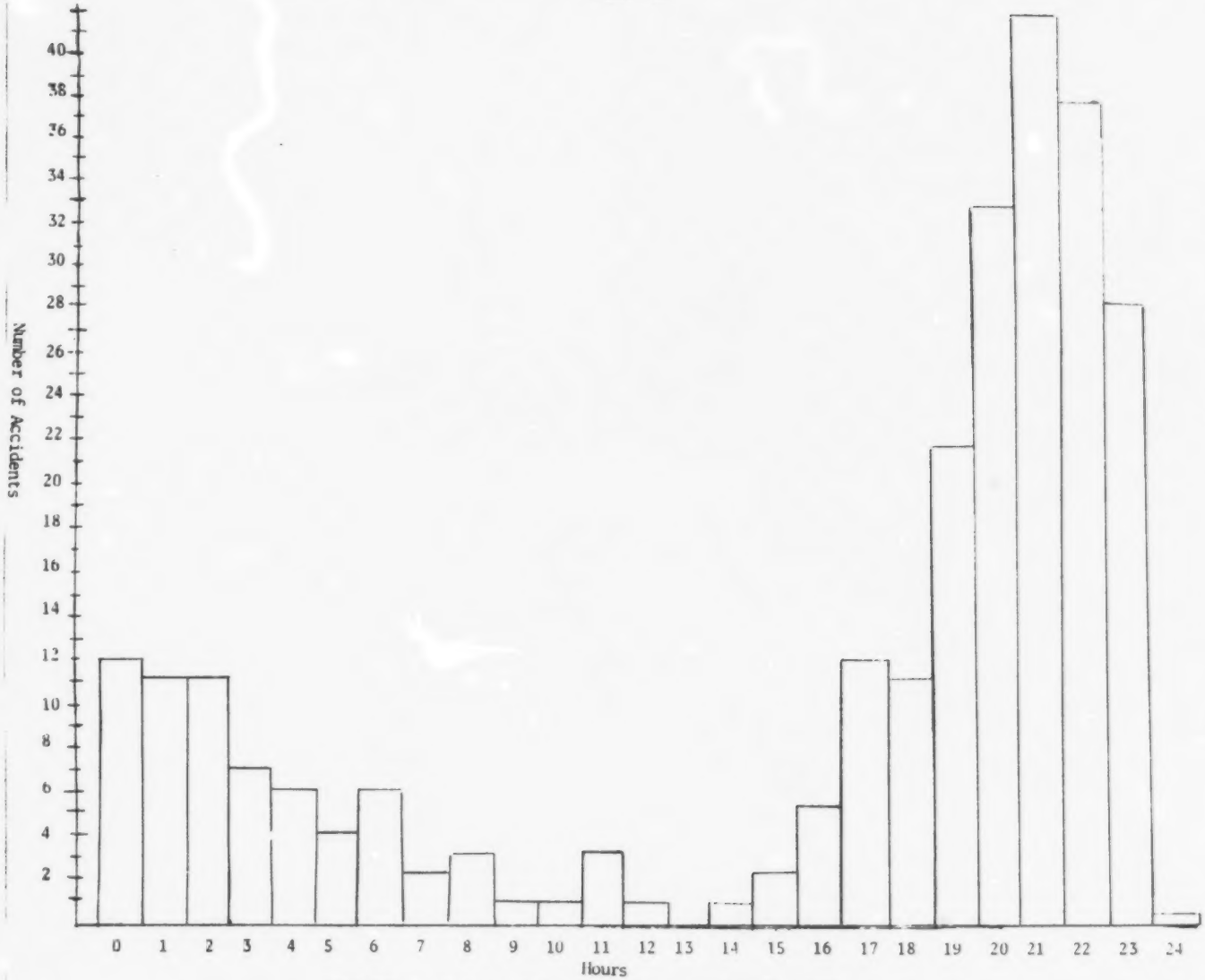
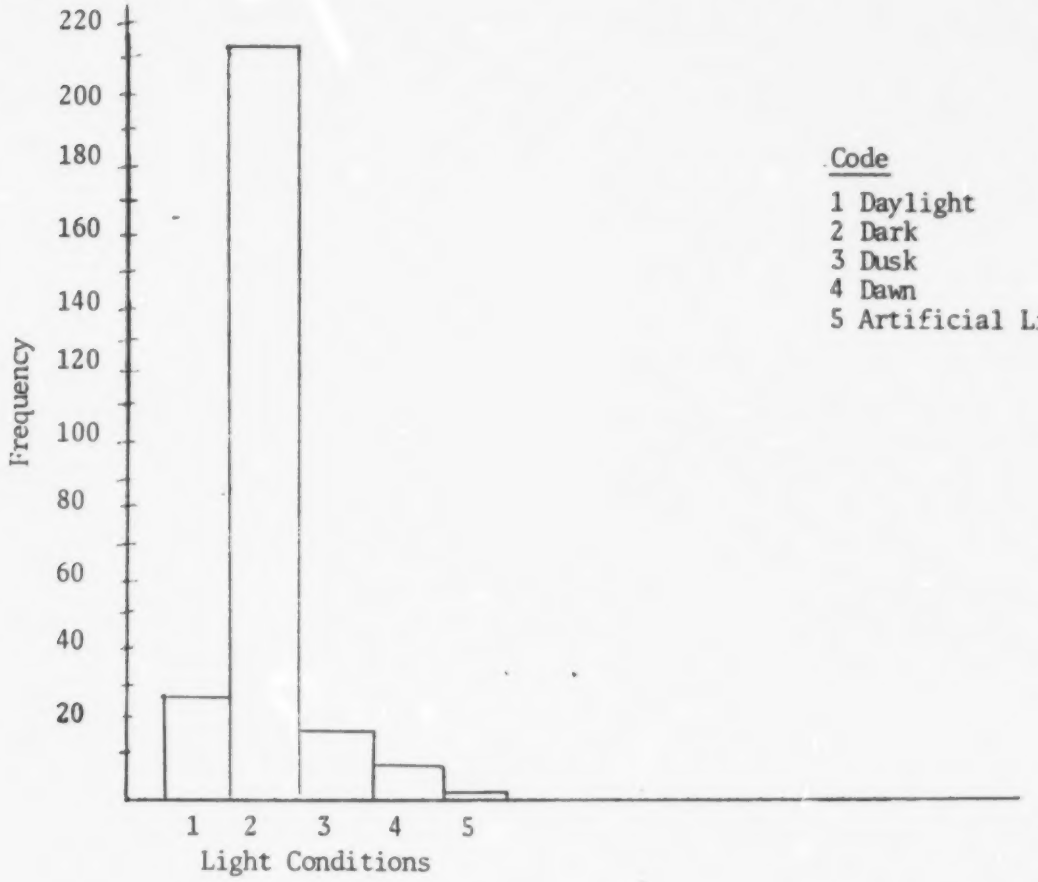


DIAGRAM D - Number of Moose Accidents per hour for 1983.



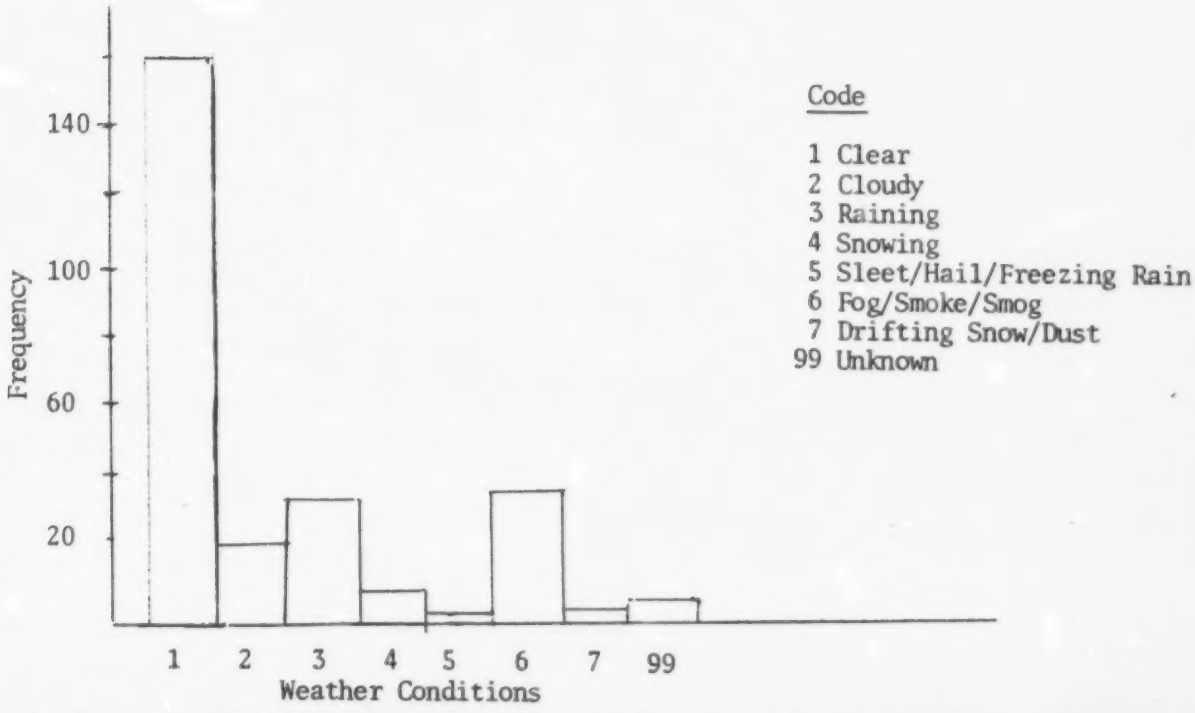
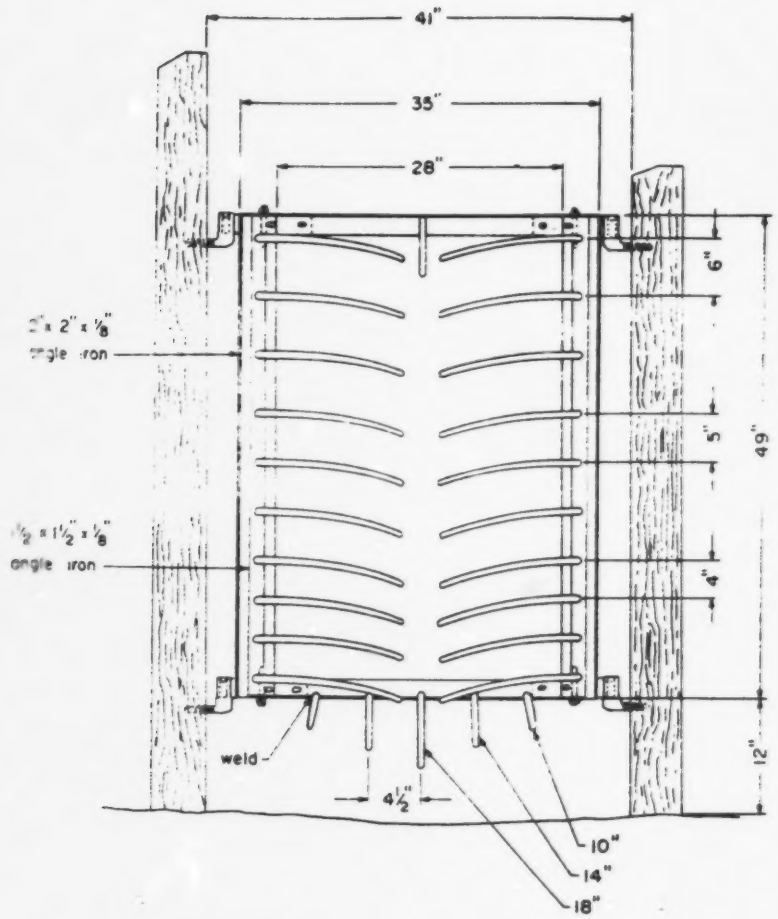
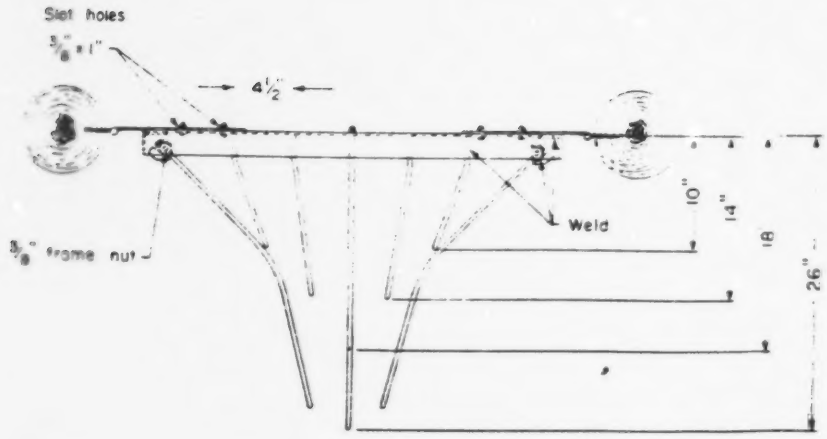


DIAGRAM E - Moose Accidents by Weather Condition and Light Condition, 1983

APPENDIX C - FENCING



FRONTAL VIEW OF ONE-WAY DEER GATE SHOWING PLANS AND SPECIFICATIONS



TOP VIEW OF ONE-WAY DEER GATE SHOWING FUNNEL OR CONE EFFECT

DIAGRAM A - Front and top view of one way gate.

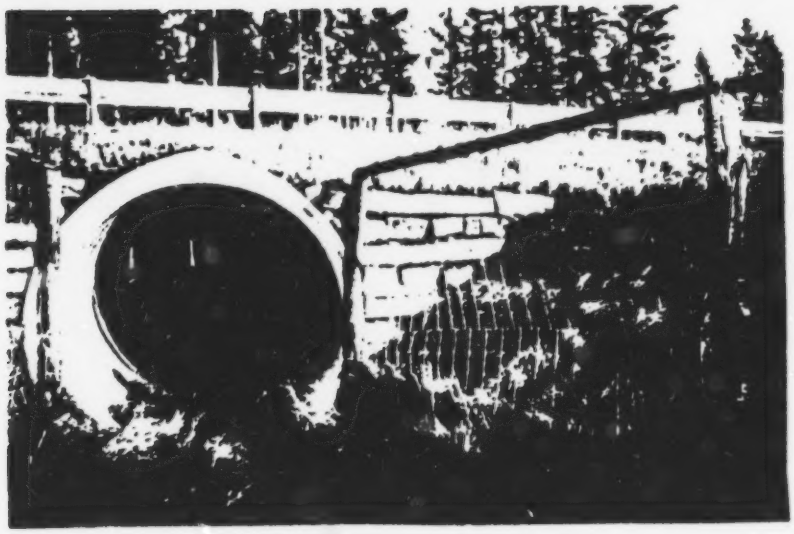


DIAGRAM B - Culvert Type Underpass

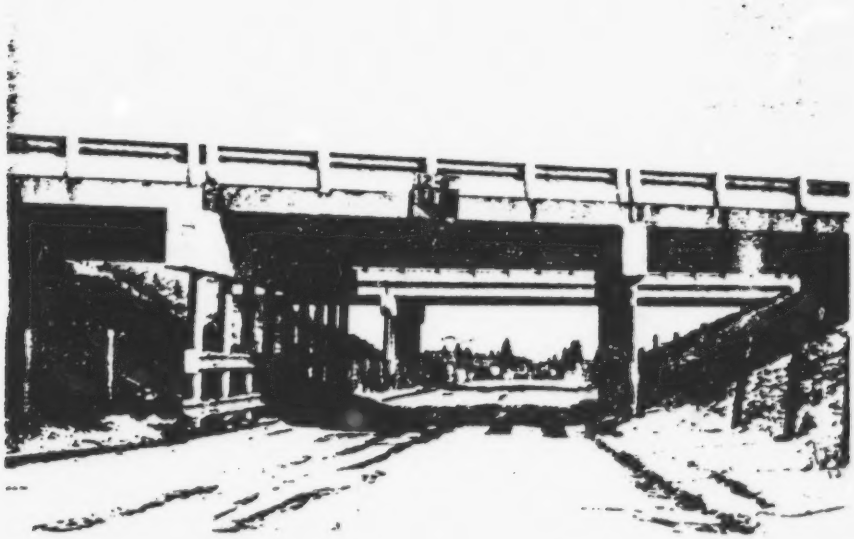


DIAGRAM C - Bridge Type Underpass

APPENDIX D - REFLECTORS

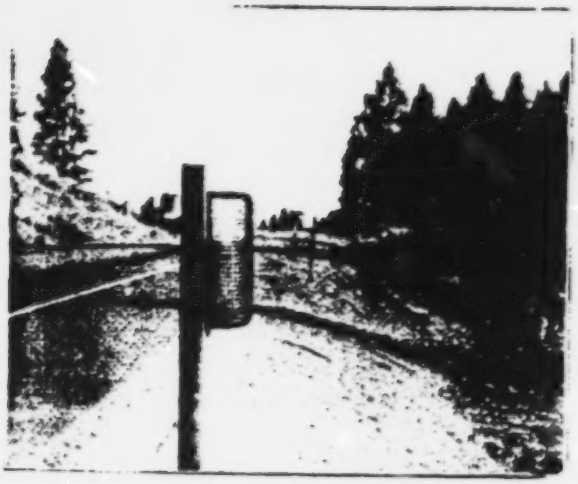


DIAGRAM A - Swareflex Reflector

SPACING OF SWAREFLEX WILDLIFE WARNING HIGHWAY REFLECTORS WHERE TREELINE OR OTHER VISUAL BARRIERS ARE PRESENT

A = the distance from the reflectors to the treeline or other visual barriers, if less than 20 meters (66ft.) on straight highways or 10 meters (33ft.) on curved highways.

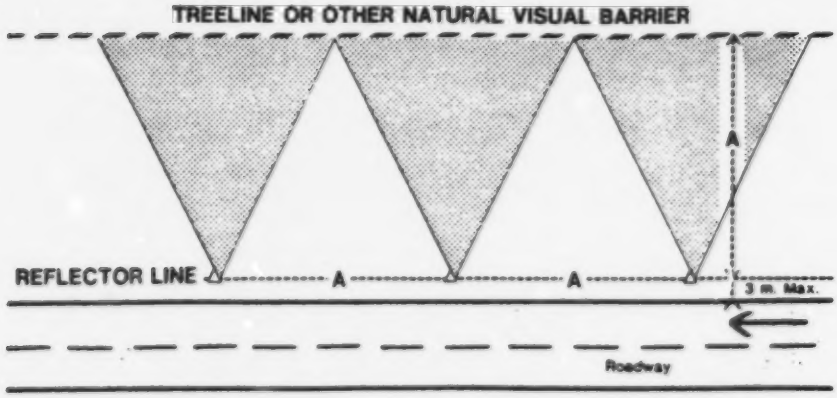
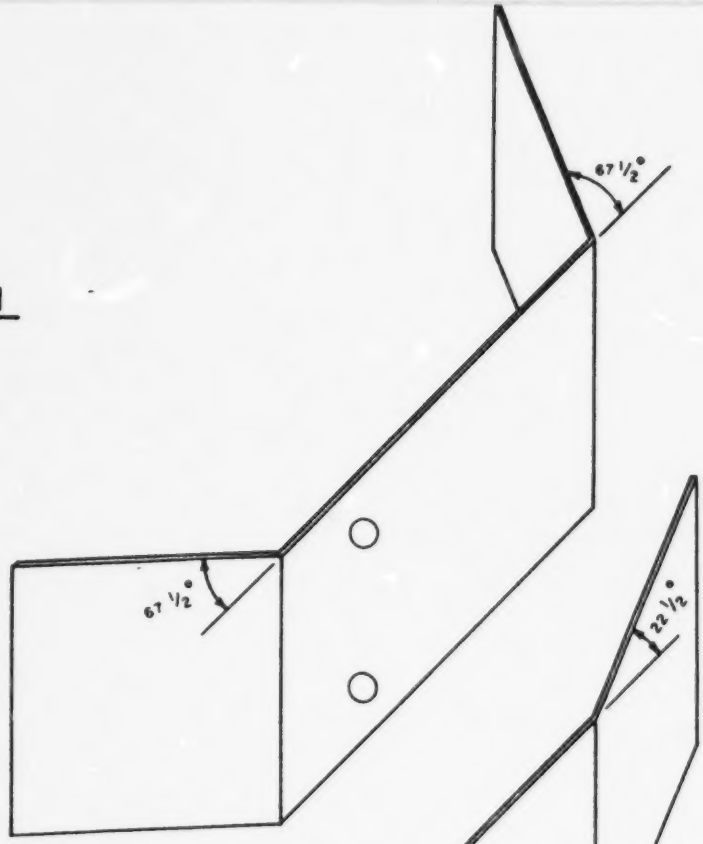


DIAGRAM B - Swareflex Optical Fence

Bracket No. 1



Note

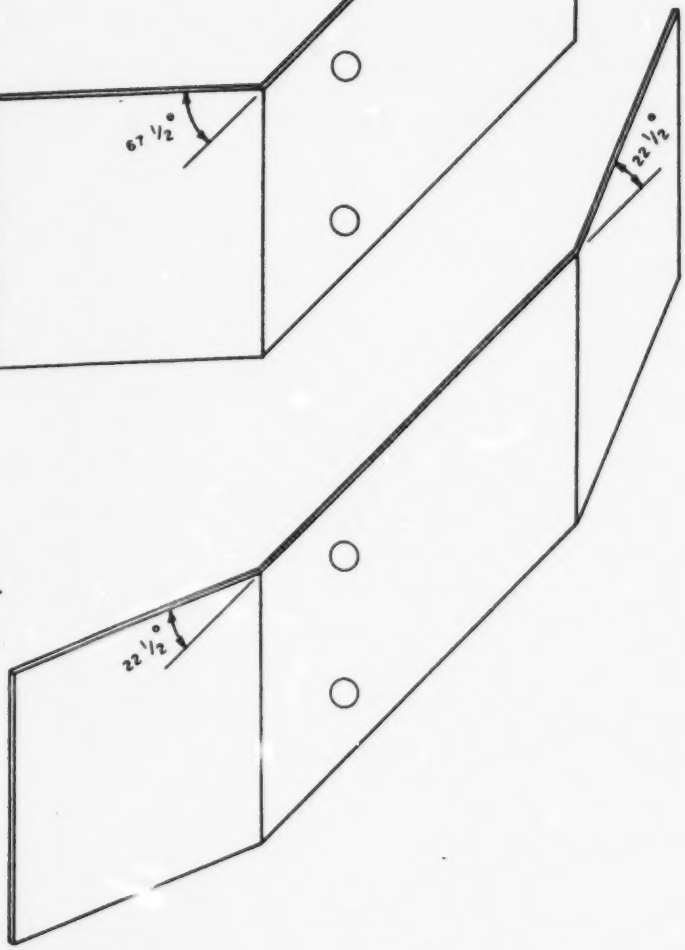
Bracket 1, Bracket 2 And 4 Mirrors = 1 Set

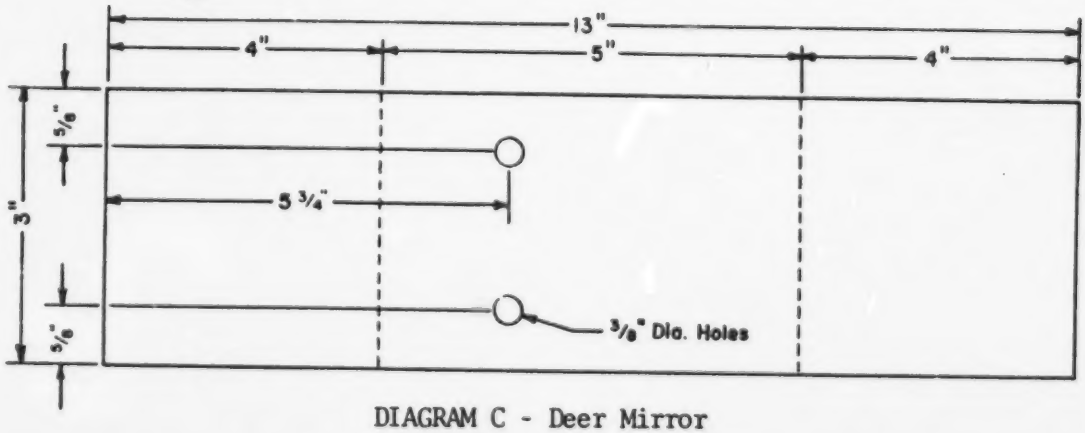
Note

Bracket To Be Manufactured Using .125 Utility Sheet Aluminum Or 12 Gauge Galvanized Steel

Same Dimensions As Bracket 1, Only Degree of Bend Differs

Bracket No. 2





Face

Chrome Reflecting Tape

DIAGRAM C - Deer Mirror

APPENDIX E - SALT ALTERNATIVES

TABLE 1 - SALT ALTERNATIVES

DEICING COMPOUND	COMPOSITION	EFFECTIVENESS AS A DEICER	COST
NaCl	Sodium Chloride Salt based	Conventional road salt used to remove snow and ice from pavement. Amount to be applied: 0 to -2 C 85 kg/km -2 to -5 C 40 kg/km -5 to -10 C 200 kg/km less than -10 used only on hazardous areas. Penetrates and undercuts ice.	$39.69 /tonne
Sand		Provides skid resistance. 0.5 m/km for a 2 line gravel road.	if purchased by contract $18.49/m^3
CaCl	Calcium Chloride Non Sodium deicer	Used to provide heat and not to melt snow and ice. Not used for ice control. Two disadvantages: - tends to keep pavement wet - melting action often on ice surface Because Nfld.'s air is so moist CaCl absorbs a lot of water from it. For this reason, CaCl cannot be used in concentrations of greater than or equal to 5% and must therefore be used with greater than or equal to 95% of another substance.	$400 /tonne
Urea	Nitrogen Fertilizer	Used on a number of airports including St. John's Airport If used on roadsides the fertilizer may enhance the attractiveness of roadside vegetation.	$356 /tonne

APPENDIX F - SOUND DETERRENTS

Prevent animal road kills with Hobi Animal Warning Alert
• Avoid animal/vehicle collisions
• Effective on vehicles travelling over 50 km per hour
• Ultrasonic sound warns animals of vehicle approach
• In-audible to humans
• Reduce chance of costly damage to your vehicle — promote safety

DIAGRAM A - 5 cm long "Moose Whistle"

APPENDIX G - BEHAVIORAL STIMULI

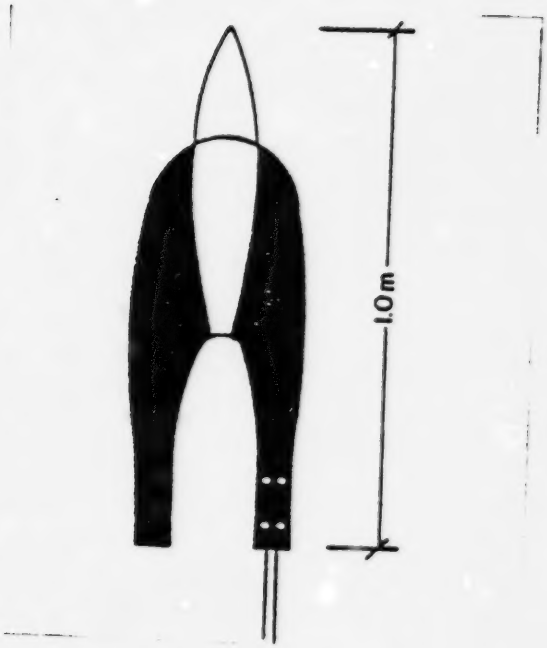


DIAGRAM A - Deer Alarm Model

DIAGRAM E - Light Animated Deer Crossing Sign

DIAGRAM C - Reflective Elk Silhouette

DIAGRAM D - Introductory Sign

DIAGRAM A - Panel Type Elk Sign

DIAGRAM B - Nonreflective Elk Silhouette

APPENDIX H - SIGNAGE

DIAGRAM F - Moose Silhouettes - Terra Nova National Park

RESEARCH REPORTS

1.	Highway Pavement Markings	79 01
2.	Studded Tires	79 08
3.	Longitudinal Pavement Markings	79 10
4.	Results Seat Belt Survey	80 01
5.	Evaluation of Non-Coning Traffic Paint	80 02
6.	Salt Spreading Techniques	80 04
7.	Extra Provincial Truck Licencing Revenues	80 11
8.	A Discussion on the Methodology to Determine Environmental Guidelines for Highway Construction	80 12
9.	Evaluation of Snowplowable Raised Reflective Pavement Markers	81 06
10.	Results Seat Belt Survey 1981 06 17	81 06
11.	Results Seat Belt Survey 1981 07 17	81 07
12.	Results Seat Belt Survey 1981 08 21	81 08
13.	Results Seat Belt Survey 1981 09 22	81 09
14.	Results Seat Belt Survey 1981 10 23	81 10
15.	Results Seat Belt Survey 1981 11 20	81 11
16.	Results Seat Belt Survey 1982 03 29	82 03
16A.	Environmental Evalution of the Grand Codroy River Bridge, Newfoundland	82 04
17.	Results Seat Belt Survey 1982 06 18	82 06
18.	Evaluation of Dura-Brite Snow Plowable Raised Reflection Pavement Markers	82 09
19.	Results Seat Belt Survey 1982 09 17	82 09
20.	Vehicle Operating Costs For Input to the User Benefit Program	82 11
21.	Results Seat Belt Survey 1982 12 17	83 01
22.	Results Seat Belt Survey 1983 03 28	83 05

23.	Evaluation of the Newfoundland Safety Council Motorcycle Training Course	83 06
23A.	Results Seat Belt Survey 1983 06 23	83 07
24.	Results Seat Belt Survey 1983 09 23	83 09
25.	Results Seat Belt Survey 1984 01 27	84 01
26.	Vehicle Operating Costs For Input to the User Benefit Program	84 04
27.	Results Seat Belt Survey 1984 07 13	84 08
28.	Maintenance Dollars Spent By Code in Each District	84 10
29.	Human Aspects of Highway Accidents in Newfoundland	85 02
30.	Benefit/Cost Analysis of the Line Road, Hearts Delight towards Carbonear	85 04
31.	Results Seat Belt Survey 1985 06 06	85 08
32.	An Evaluation of the Department of Transportation Hydroseeding Methodology	85 08
33.	Benefit/Cost Analysis of Route 420 and Route 421, Trans Canada Highway Towards Hampden and Jacksons Arm	85 11
34.	Moose Vehicle Collisions in Newfoundland	85 12